ISPMS SB RAS

Institute of Strength Physics and Materials Science
of Siberian Branch Russian Academy of Sciences

Deformation of Hadfield steel single crystals by dry sliding friction with the normal load $[\bar{1}\bar{1}0]$/friction force orientations $[\bar{1}10]$ and [001]

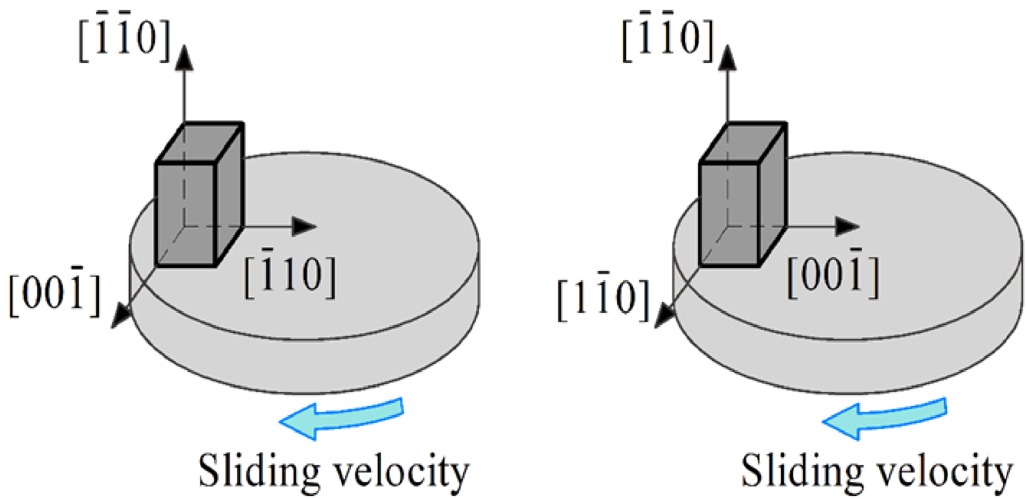
Novitskaya O.S., Laboratory of Physics of Surface Hardening

Problem

- To stady the shear pattern near the side face of Hadfield steel single crystals with the same normal load axis but different friction force axes.
- To correlate it with the calculated slip and twin stresses induced by the normal pressure and friction forces.
- To analyze changes in the dislocation structure with distance from the worn surface.

Test procedure

Materials: samples – Hadfield steel single crystals, counterbody – 105WCr6 steel hardness of 60 HRC.
Chemical composition: C – 1.1%, Mn – 12.5%, Si – 0.4%, Ni – 0.15%, Cr – 0.29%, V – 0.035%, Co – 0.04%, Ti – 0.007%, and the rest is Fe.



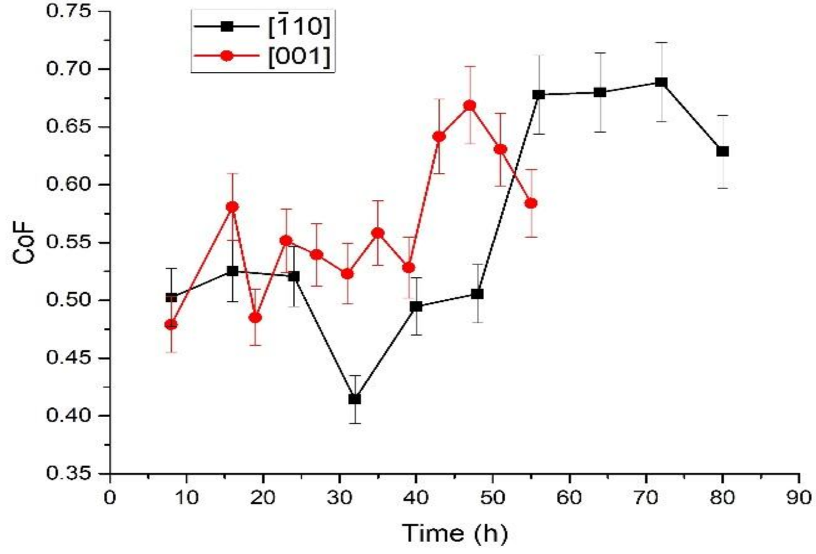
The friction test configurations

Test conditions:
1) normal load of 21 N
2) sliding velocity of 0.1 m/s
3) dry sliding friction
4) consistent tests under constant conditions

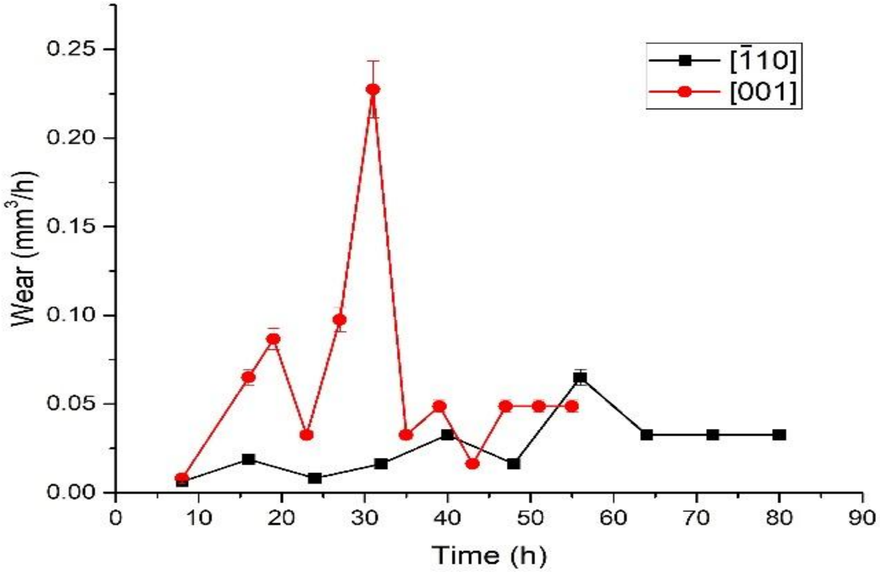
Research technique

- Sliding friction –”TRIBOtechnik” tribometer.
- Single crystal surfaces were inspected using an Olympus LEXT OLS4100 confocal microscope.
- The deformation structure of surface and near-surface layers were investigated in cross section aftertribologicaltests by transmissionelectronmicroscope (TEM) JEOL JEM-2100F.

Wear and coefficient of friction



a



b

Time variation of the friction coefficient (a) and wear rate (b) for Hadfield steel single crystals with different crystallographic orientations

Stress-strain analysis

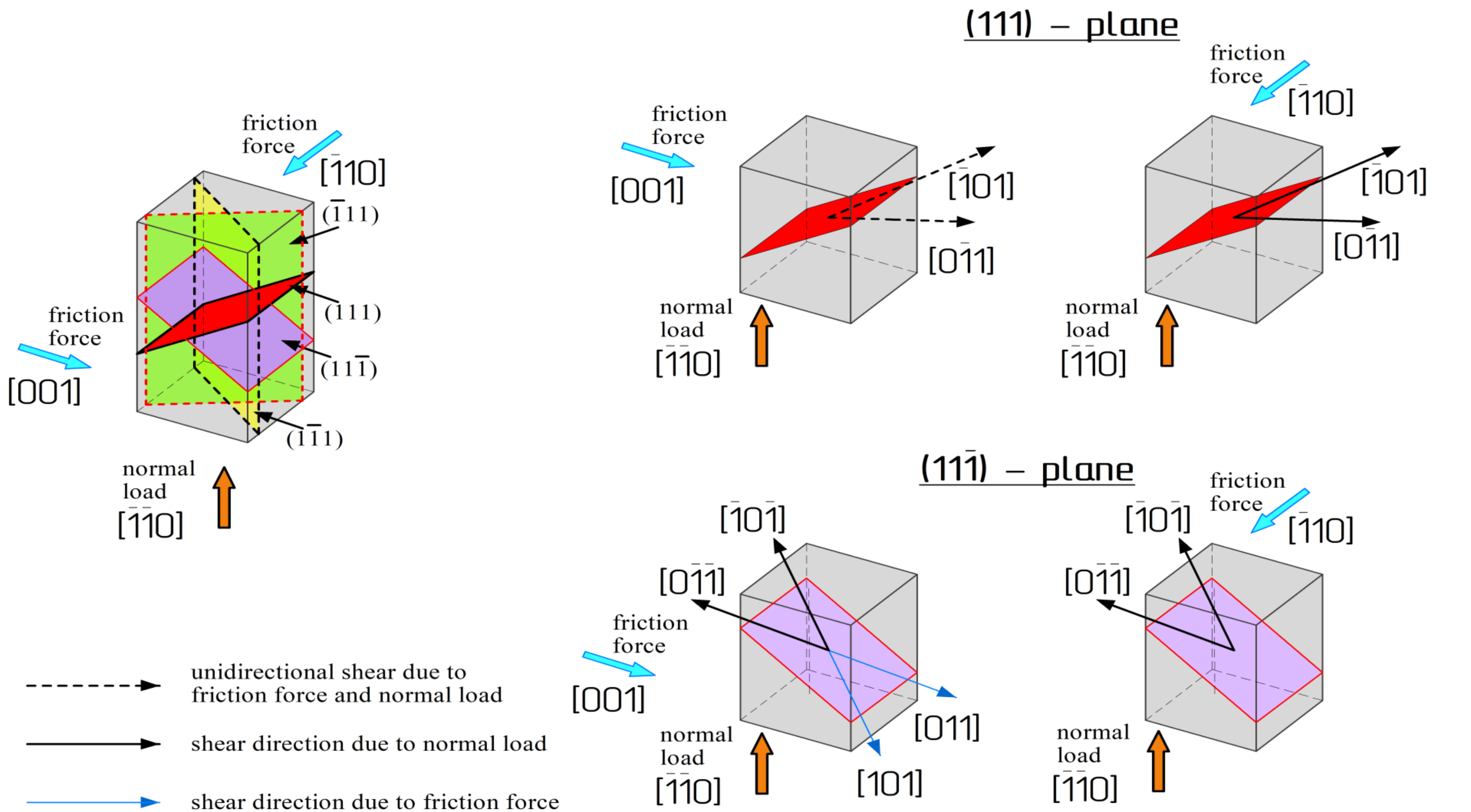
Maximum nominal stresses for the normal load/friction force orientations $[\bar{1}\bar{1}0]/[\bar{1}10]$

Slip plane	Close-packeddirection	Total slip stress(τ_{sl},MPa)	Partial dislocation Burgers vector	Total twinning stress(τ_{tw},MPa)	Twinning-to-slipstressratio(τ_{tw} / τ_{sl})
(111)	$[\bar{1}01]$ $[0\bar{1}1]$	0.66 0.66	$[\bar{1}\bar{1}2]$	0.76	1.15
$(11\bar{1})$	$[0\bar{1}\bar{1}]$ $[\bar{1}0\bar{1}]$	0.66 0.66	$[\bar{1}\bar{1}\bar{2}]$	0.76	1.15

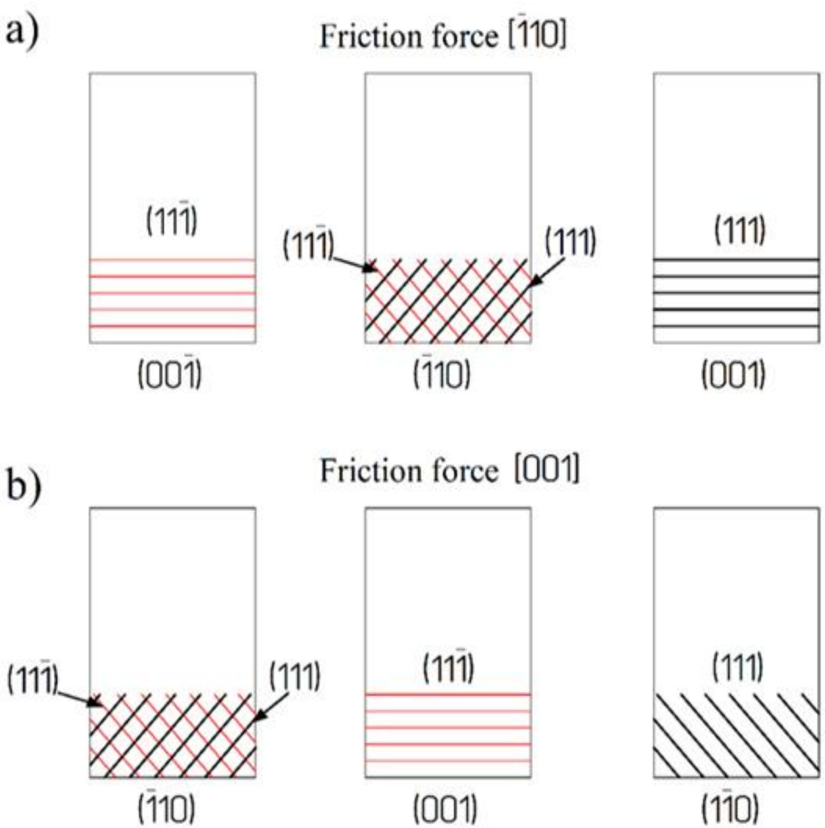
Maximum nominal stresses for the normal load/friction force orientations $[\bar{1}\bar{1}0]$ /$[001]$

Slip plane	Close-packeddirection	Total slip stress (τ_{sl},MPa)	Partial dislocation Burgers vector	Total twinning stress (τ_{tw},MPa)	Twinning-to-slipstressratio(τ_{tw} / τ_{sl})
(111)	$[0\bar{1}1]$ $[10\bar{1}]$	1.03	$[\bar{1}\bar{1}2]$	1.19	1.05

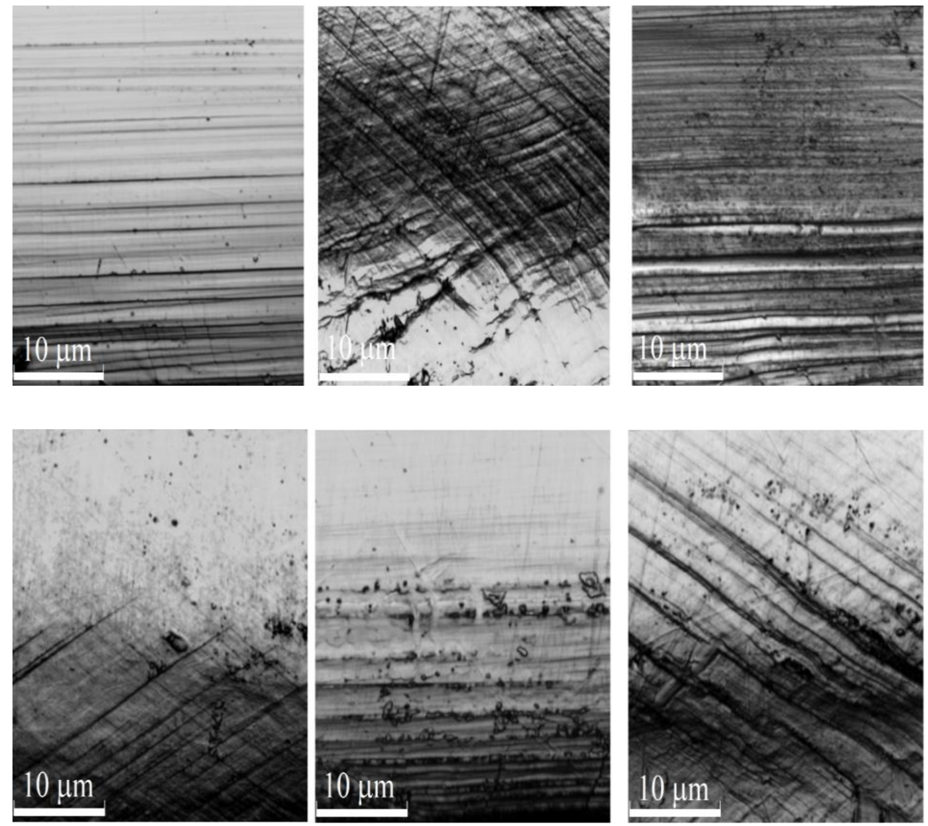
Shear directions and slip planes in Hadfield steel single crystals with the normal load/friction force orientations $[\bar{1}\bar{1}0]/[\bar{1}10]$ and $[\bar{1}\bar{1}0]/[001]$



Slip band patterns

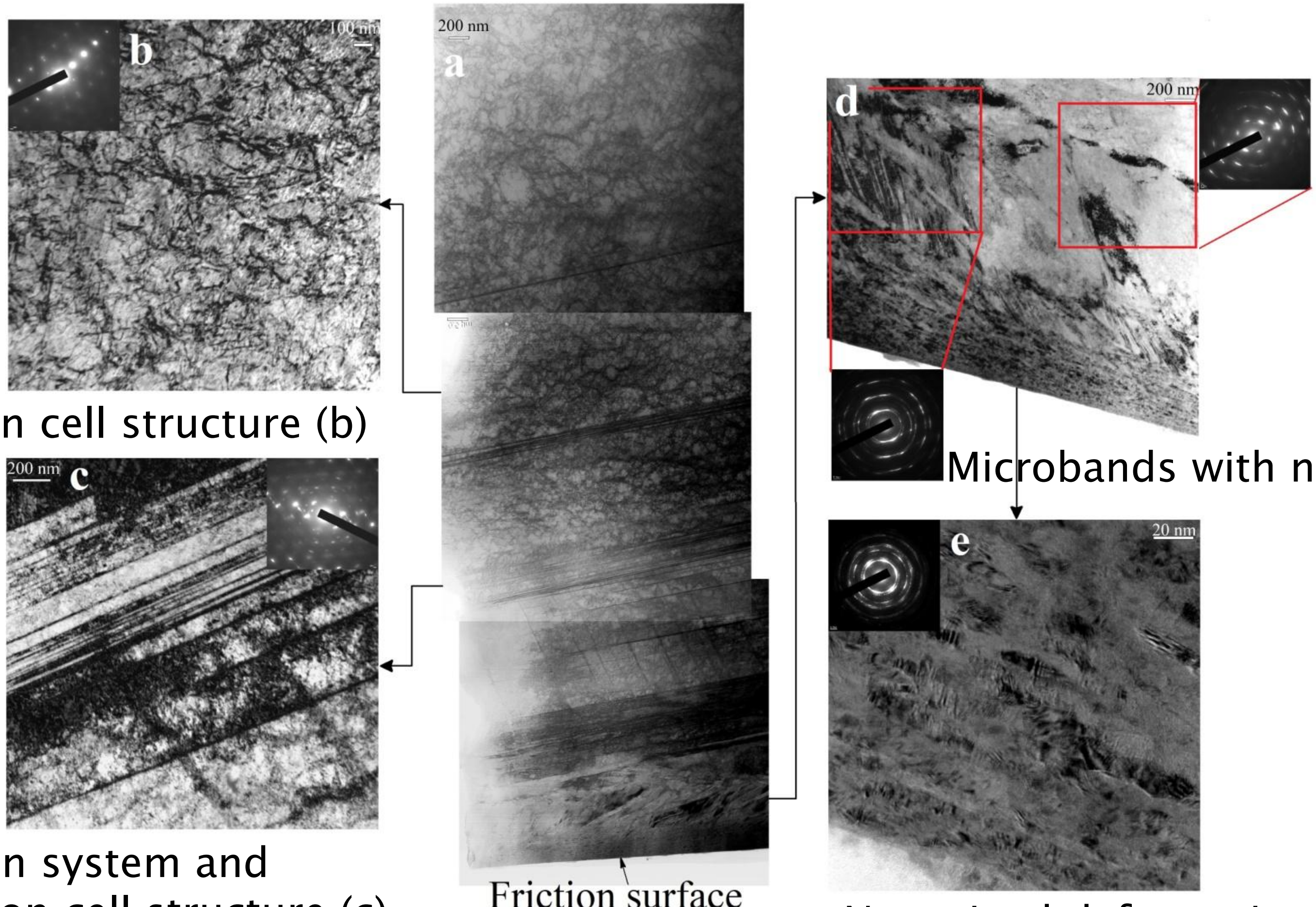


Surface deformation pattern



TEM

Dislocation structure changes from the surface into the bulk of the material



Dislocation cell structure (b)

Microtwin system and dislocation cell structure (c)

General view (a)

Microbands with nanotwins (d)

Nanosized deformation bands with nanotwins (e)

Conclusion

- The coefficient of friction does not change monotonically in both types of single crystals.
- According to the analysis of the dislocation structure there are the following zones with different deformation mechanisms:

* dislocation slip zone,
* inactive twinning zone,
* active twinning zone (one or two microtwin systems),
* zone of deformation microbanding,
* zone of microbands with nanotwins,
* nanofragmentation zone,
* zone of interaction between the sample material and the disk (mixing zone).

Thank you for your attention